REMARKS

Claims 1-32 are pending in the application, where Claims 1, 11, 21, 22, 27 and 32 are independent claims.

Claims 1-8, 10-18 and 20-32 have been rejected under 35 U.S.C. § 103 as being unpatentable over Poggio et al. (U.S. Patent No. 5,642,431) in view of Kung et al. (U.S. Patent No. 5,850,470). Further Claims 9 and 19 have been indicated to be allowable if rewritten in independent form.

New independent Claims 35 and 36 recite Claims 9 and 19 respectively in independent form. Claim 36 is a method claim, Claim 36 is the parallel system claim. New independent Claim 37 similarly recites a computer program product having instructions for performing the method of Claim 9. Thus the invention subject matter of Claims 9 and 19 have been rewritten in independent form and presented as new claims 35-37. Acceptance is respectfully requested.

Support for amendments to Claim 10 is found at least on Specification pages 11 and 13-14 as originally filed. Support for new Claims 33 and 34 is found at least on Specification page 4, lines 1-13 and page 3, lines 23-28 as originally filed. No new matter is introduced.

The foregoing claim amendments represent original base Claims 1, 11, 21, 22, 27 and 32 rewritten to emphasize the following features of the present invention:

(1) The present invention provides a faster classification function than prior art classification functions. Using a cascaded approach, the present invention quickly determines if a face could potentially appear at a given scale and location. In some cases this can be done in 20 or less operations for a subwindow (i.e., patch) of the integral image. In other embodiments, at least 50% of the subwindows are correctly classified with 33 or less operations per subwindow. The present invention chains homogenous types of classification functions together in a cascade of classification functions. This approach of the invention allows the object detector to quickly discard subwindows whose response to the homogeneous classification functions is not sufficiently strong. Also the object detector continues to process through the cascade only those subwindows whose response indicates the likelihood of an instance of the object in the subwindow. See Specification page 4, lines 1-10.

(2) Almost all previous approaches to object detection perform a large amount of work (large number of computations by a digital processor) in the scanning process alone. The conventional process alone often requires 50-100 operations per pixel. One reason for this number of operations is that the computer must perform interpolation calculations between pixels as part of the scaling process. On the other hand, an object detector of the present invention engages in much less initial image processing compared to prior art approaches. The present invention creates and uses an image representation called an integral image, in contrast to typical prior art approaches that use an image pyramid. In a preferred embodiment, the present invention computes the integral image in less than about 5 to10 operations per pixel. Nevertheless, the object detector of the present invention detects objects (e.g., faces) at any scale and location. See Specification page 3, lines 3-20.

(3) Prior art approaches evaluate pixels to identify an instance of an object in a subwindow, or rely on complex nonlinear operations to identify a subwindow that is likely to contain an instance of an object. The present invention uses a feature representation, which detects objects (e.g., faces) by looking for the appearance of features, which have basic geometric shapes (e.g., based on rectangular boxes). These simple features, combined with the integral image, allow for a computationally efficient approach to identifying whether a given area in a subwindow (e.g., given boxes) has a characteristic of interest (that may identify an instance of the object, usually along with other features). This approach of the present invention is more efficient than looking at the pixels of the image itself as is done in many prior art approaches. See Specification page 3, lines 21-30.

No new matter is introduced.

Neither Poggio nor Kung imply or suggest a fast classification or quick object detection by employing a cascade of homogeneous classification functions as in the present invention. In particular, the cited portions of Poggio (col. 3, lines 52-53 and lines 53-56) only indicate that at the window located at the stated position and scale, the Poggio system "attempt[s] to classify the

enclosed image pattern as being either a face or not a face." This discloses the application of a general detection algorithm at a specific location and scale, and does not address the application of a cascade of homogeneous classification functions for the purpose of object detection as in the claimed invention.

The reference to Kung does not disclose a cascade of homogeneous classification functions. The channel classifiers of Kung are run concurrently. Both Fig. 5 and the Kung reference to "lateral fusion of information" (col. 11, line 30) indicate that the outputs of the channel classifiers are to be combined before a decision is made to accept or reject the input window under consideration. Each of these channel classifiers feeds into another classifier (60, Fig. 5) that performs the lateral fusion. There is no indication that the output of a single channel classifier provides a suitable basis for a cascade of classifiers.

Further, the channel classifiers described in Kung are not homogeneous. In Kung, col. 11, lines 26-27 indicates that the channel classifiers receive "input vectors either from different sensors or from a portion of a higher dimensional feature vector". This implies that the input is different, and therefore that the function of each channel is different. Fig 5 of Kung also clearly indicates that channels 1 and 2 receive different input. Furthermore, the output classifier (Fig 5, 60) is clearly different in both input and output to the channel classifiers. Thus, Kung does not disclose homogeneous classifiers (classification functions) as claimed in the present invention.

Lastly, neither Poggio nor Kung imply or suggest a quick object detection system/method, for example, an average process rate of less than 200 arithmetic operations for each subwindow or in a manner enabling real time application. Neither Kung nor Poggio describe a system in which the average number of operations per subwindow is intrinsically independent of the dimensions of that subwindow. The use of integral images together with rectangular features and a cascade of homogeneous classification functions in the present invention ensures an average operation count that is independent of the dimensions of the subwindow. To Applicants' knowledge, comparable systems known in the art (including those of Kung and Poggio) require either scaling of the subwindow (requiring at least one arithmetic operation per pixel), or usage of algorithms taking inputs of varying dimensions depending on the subwindow under consideration. Thus, neither Poggio nor Kung imply or suggest the use of the cascade of

homogeneous classification functions to quickly detect objects as now claimed in the present invention.

Thus no combination of the cited art makes obvious the present invention as now claimed in each base claim reciting "...employing the cascade of homogeneous classification functions...quickly detect instances of the certain objects in the image in a manner enabling real-time application..." (or similar language). Support for the foregoing claim amendments is found at least on Specification page 4, lines 1-13 as originally filed. No new matter is introduced.

By virtue of their dependency, each dependent claim inherits the distinguishing "quick detection...enabling real-time application" limitation of the respective base claim. Thus for the same reasons as above, the inventions of the dependent claims are not obvious in view of the cited art.

Accordingly, the § 103 rejection of Claims 1-8, 10-18 and 20-32 is believed to be overcome. Acceptance and reconsideration is respectfully requested.

CONCLUSION

In view of the above amendments and remarks, it is believed that all claims (Claims 1-37) are in condition for allowance, and it is respectfully requested that the application be passed to issue. If the Examiner feels that a telephone conference would expedite prosecution of this case, the Examiner is invited to call the undersigned.

Respectfully submitted,

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